

### Abstract

To protect the water supply in our nation's cities, the Idaho National Laboratory (INL) built a test facility to evaluate how pollution moves in a water system. Mitigating harmful pollutants in municipal water distribution networks is crucial for the protection of city residents.

JARVIS Engineering worked with the INL to create the plans for a proposed expansion of the current, straight-line Water Security Test Bed to better model a city block.

An expanded looping system was designed by the JARVIS team and modeled in EPANET to provide flow values for various scenarios.



Figure 1. Test Site

### Alternatives

To solve the problem at hand, JARVIS started by analyzing multiple alternatives. The five viable alternatives selected by the JARVIS team were:

- 1. Atomic City** - Purchasing Atomic City, Idaho, and using this small town's existing water infrastructure to model a city system.
- 2. Client Preference** - Expand the current straight-line pipe into a looping bed by building a main loop, and then adding subloops.
- 3. Subloops First** - Expand the current straight-line pipe into a looping bed by building subloops then an outer main loop.
- 4. Straight Line pipe** - Extending the current straight-line pipe into a longer straight-line pipe.
- 5. Do-Nothing** - Keeping the current test bed the way it is.

### Decision Matrix

Each alternative was ranked in its ability to meet each design criteria category, with 1 (white) being worst and 5 (dark blue) being best. The total analysis can be seen in the Pugh Matrix below. The design criteria analyzed for each alternative included construction cost, constructability, land usage and environmental impact, expansion potential, functionality/results, and operation and maintenance cost.

Criteria	Criteria Value	Atomic City	Client Preference	Subloops First	Straight Line Pipe	Do-Nothing
Construction Cost	0.1	1	2.5	2.5	4	5
Constructability	0.2	4	2	1	3	5
Land Usage & Environmental Impact	0.1	1	5	4	3	2
Expansion Potential	0.2	1	4.5	4.5	2	0
Functionality / Results	0.3	5	3	4	2	1
Operation and Maintenance Cost	0.1	1	3	2	4	5
<b>Total</b>	<b>1.0</b>	<b>2.8</b>	<b>3.25</b>	<b>3.15</b>	<b>2.7</b>	<b>2.5</b>
<b>Gross Point Value</b>		<b>13</b>	<b>20</b>	<b>18</b>	<b>18</b>	<b>18</b>

Figure 2. Pugh Matrix

### Selected Alternative

After ranking each alternative in each design criteria category, the Client Preference option was determined to be the best alternative. Expanding the current straight-line pipe into a looping system by building a main loop and subloops.

The project was designed in AutoCAD Civil3D and in the Environmental Protection Agency Network (EPANET). A pipe network was first modeled in Civil3D for scale and then moved to EPANET to better model dynamic flow properties. The EPANET model could be adjusted into different looped combinations to see how pressure and flow changed in the pipe network.

Components of the Client's Preference alternative include 1 tank, 2 hydrants, 27 valves, 2 pumps, and 2280 feet of pipe. The final construction cost of this selected alternative is \$311,896.

### Design and Results

EPANET software produced distribution of flow and distribution of velocity graphs, along with maps of pressure and flow throughout the system. The water system model was reconfigured into six different loops to show different combinations of pressure, flow, and velocity. The INL will be able to use the model to simulate flow through many different pipe configurations in the water test bed. Along with the model, JARVIS produced an EPANET Standard Operating Procedures document and tutorial video for the INL and future student use.

Figure 3 shows a model of the full designed network. Each pipe is a different color, corresponding to the flow in the system as indicated by the legend. The same can be said for the pressure at each node. Six different flow and pressure maps were generated by the JARVIS team using EPANET, one for each modeled pipe configurations. Different configurations are modeled by turning select pipes on and off in the network

With the looping water model, the INL can model more complex contaminate scenarios compared to their current straight line pipe configuration. EPANET also has a feature which will allow the INL to predict the water quality through the pipe loop before testing different chemicals. Model results can be compared with actual test results to determine possible efficiencies in the system, which can be used to improve municipal water systems nationwide.

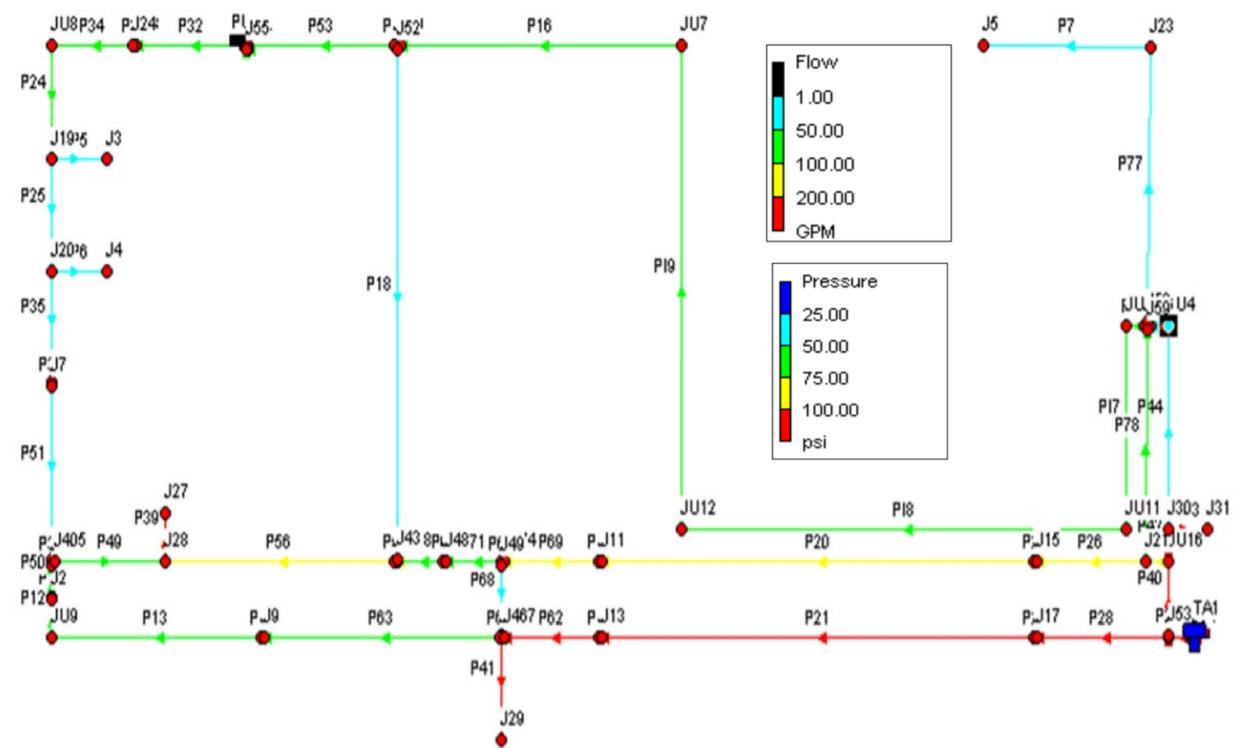


Figure 3. Full Network Model Design

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